Outcomes of secondary interventions after abdominal aortic aneurysm endovascular repair

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Purpose: **We assessed the distribution of secondary interventions after aortic stent grafting (EVAR) performed to treat infrarenal abdominal aortic aneurysm (AAA), and evaluated clinical success and survival in patients who underwent a secondary procedure (group 2) compared with patients who did not undergo a secondary procedure (group 1).**

Methods: **Two hundred fifty patients (mean age, 71.3 years) with asymptomatic AAAs (mean aneurysm diameter, 54.5 mm) underwent treatment with commercially available stent grafts. Mean follow-up was 28 months (median, 25 months). Secondary procedures were defined as any additional procedures performed after initial graft placement to treat endoleak, migration, kinking, stenosis, or occlusion. Overall clinical success was defined according to reporting standards of the Society for Vascular Surgery/American Association for Vascular Surgery.**

Results: **Sixty-eight patients (27%) required 112 secondary procedures, with a mean time from initial graft placement of 18.2 months. Patients who received grafts since removed from the market required more secondary procedures (59%, procedure:patient ratio) compared with patients who received devices still on the market (21%; $P = .001$). Thirty-six patients (53%) required a single secondary procedure, 24 patients (35%) required two procedures, 5 patients (10%) required three procedures, 2 patients (3%) required four procedures, and 1 patient required five secondary procedures. Ninety-eight procedures (87%) were performed with endovascular methods, including placement of 42 additional covered stent grafts (36 iliac, 6 aortic), with a success rate of 85%; 35 embolization procedures (21 lumbar, 9 internal iliac artery, 5 mesenteric), with only 23 (65%) successful; 14 angioplasty procedures, with 85% successful; 4 thrombolysis procedures, 2 of them successful (50%); and 3 successfully placed new endografts within a previous endovascular graft. Surgical secondary operations included nine femorofemoral bypass procedures and three femoral thromboendarterectomies, all of which remain patent; one cerclage of an external iliac limb; and one laparoscopic repair of a type II endoleak, which was successful. Overall clinical success rate for EVAR was 84% (211 of 250) in this series. Clinical success rate in groups 1 and 2 was 91% (166 of 182) versus 66% (45 of 68; $P = .001$) if all endoleaks on the most recent computed tomography scans are taken into account, and 94% (171 of 182) versus 76% (52 of 68; $P = .001$) if type II endoleak without aneurysm growth is not considered failure. The survival rate and rupture-free survival in groups 1 and 2 were, respectively, 97.7% ± 1.0% and 98.5% ± 1.4% at 1 month, 95.9% ± 1.5% and 96.9% ± 2.1% at 6 months, 94.4% ± 2.0% and 93.2% ± 3.4% at 1 year, and 80.8% ± 5.2% and 88.5% ± 5.0% at 3 years ($P = .273$, log-rank test).**

Conclusion: **With close follow-up and a significant number of secondary operations, this 8-year experience has not included any aneurysm ruptures to date. Secondary operations did not lead to increased mortality, but were associated with more surgical conversions and with a higher clinical failure rate. (J Vasc Surg 2004;39:298-305.)**

More than 10 years after the report by Parodi et al[1] endovascular treatment of abdominal aortic aneurysm (AAA) has become popular in the vascular community. Proved advantages are less blood loss, shorter hospitalization time, decreased need for use of the intensive care unit, less severe postoperative complications, and more rapid recovery.[2,3] On the other hand, extensive follow-up studies are recommended after endovascular repair, and repeat interventions are required in 12% to 28% of cases.[4-7] Outcomes of secondary interventions have not been extensively evaluated and reported.[8]

The purposes of the current study were to report our experience with secondary interventions after endovascular AAA repair in a single academic institution and to assess the outcomes in terms of survival and efficacy.

METHODS

From January 1, 1995, through December 31, 2002, evdovascular stent grafts were placed in 268 patients. Data analysis was limited to 250 patients who received treatment of nonruptured atherosclerotic abdominal aneurysms. Eighteen emergent procedures, nonatherosclerotic aneurysms, and aneurysms limited to the iliac arteries were excluded. All postoperative events which occurred until April 2003 were taken into account.

Data were prospectively entered into a specifically written data base (Logit; Jean Meunier, Fontenay sous Bois, France). This database was designed with a large emphasis on patient follow-up. The software was programmed to

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assess, on a monthly basis, overdue examinations and missing data. The patients were placed in a strict surveillance protocol. A part-time secretary was hired to telephone patients to ensure scheduling and compliance. At the appropriate follow-up intervals patients were examined, and their diagnostic studies were reviewed by senior vascular surgeons. For patients who died outside of the hospital, general practitioners were interviewed to assess whether death was related to aneurysm rupture or to other causes.

Postoperative follow-up included clinical examination, abdominal plain radiography, duplex scanning, and computed tomography (CT) at 1, 6, 12, and 18 months, and yearly thereafter.

Secondary procedures were defined as any additional procedures performed to treat endoleak, graft migration, kinking, stenosis or occlusion, and landing site enlargement, while leaving the primary stent graft in place.

Patients were divided into two groups. Group 1 included patients in whom secondary procedures were not necessary or not feasible; group 2 included patients in whom a secondary procedure was performed. Age, sex, AAA diameter and extent, preoperative comorbid conditions defined according to Society for Vascular Surgery/ISCVS risk score, and type of grafts were compared.

We investigated the results of each type of secondary procedure according to the intended goal, and for groups 1 and 2 compared the role of grafts used, survival rate, and clinical success as defined by the Committee for Reporting Standards for Endovascular Repair.[9]

Indications for secondary intervention

Endoleak. Type I (proximal and distal), type III, and type IV endoleaks were aggressively treated when technically accessible. Type II endoleaks were treated if they persisted on at least two subsequent CT examinations or if the aneurysm diameter was greater than 5.5 cm or had enlarged by more than 10%.

Migration. Proximal downstream or distal upstream graft migration was treated when the covered tips of the endovascular graft came close (<0.5 cm) to the aneurysmal disease.

Kinking. Severe kinking (>90 degrees) of limbs grafts was treated preemptively.

Stenosis and occlusions. All symptomatic stenotic or occlusive lesions that developed in either the grafts or the iliac or common femoral arteries distal to the grafts were treated aggressively, as were hemodynamically significant stenoses detected on routine duplex scans. Conversely, asymptomatic stenoses or occlusions were treated conservatively.

Landing site enlargement. Common iliac aneurysms adjacent or distal to the graft landing zone were treated with additional stents.

Indications for surgical conversion. Patients with failed endografts who were fit enough to undergo open surgery were operated on after endovascular attempts failed, or when endovascular means were not technically feasible or were hazardous.

Statistical analysis. The χ^2 test, Mann-Whitney test, and Student t test were used when appropriate. Survival data were assessed with life table analysis, and compared with the log-rank test.

Operative techniques. A variety of techniques were used, depending on the indication for secondary intervention, nature of the initial grafts, and type of endovascular tools available at the time of the secondary procedure.

Balloon angioplasty with or without stenting. Stenoses that developed in the external iliac artery distal to the graft were treated with balloon angioplasty through the ipsilateral groin. Stents were placed only in case of poor results assessed on intraoperative completion angiograms and with pressure measurements. In the event of twisting within a nonsupported graft, long self-expandable stents were placed to open the stenotic portion and prevent displacement of the twist proximally or distally along the graft. Kinking in fully supported grafts was treated either by placing a new stent within the kinked limb or with femorofemoral grafting when a stent could not be placed. In the latter case the compromised limb was either ligated or occluded with an occluder device (Cook, Charenton le Pont, France). Stenoses that developed at the junction of the modular components were treated with either balloon-expandable stents or a new covered stent graft.

Iliac and aortic extensions and cuffs. Iliac extensions (Boston Scientific, St Quentin en Yvelines, France; Medtronic, Boulogne Billancourt, France; Cook) were placed percutaneously or after a short inguinal incision, with products from the same or another company. When the extension required placement into the external iliac artery and crossing of a patent hypogastric artery, the origin of the hypogastric artery was embolized with coils beforehand. This was necessary because all of our secondary iliac extensions required going down to the external iliac level, because of common iliac enlargement or aneurysm formation.

Aortic cuffs were introduced from the groin with a pigtail catheter placed in the aorta from the brachial artery (left side in most cases). The position of the renal arteries during deployment was assessed via a wire selectively placed beforehand (Fig 1, online only). In cases of severe aortic angulation an extra-large Palmaz stent (Cordis, Issy les Moulineaux, France) was placed across the renal arteries, with the distal portion extending down into the graft. The aortic cuff was then placed inside the Palmaz stent.

Treatment of disconnections. When modular components separated, we tried to catheterize both components from the groin and to place a new covered stent within the previous graft (Fig 2, online only).

Endovascular conversion. This strategy involved placement of a new aortouniiliac graft within the previous graft. If the first graft was bifurcated, the contralateral limb was blocked with an occluder. Flow was restored with a femorofemoral bypass or an iliofemoral bypass graft. Endovascular conversion was particularly useful in cases of failed attempts to treat severe limb kinking, disconnection with type III endoleak and type I proximal endoleak, and migra-

Table I. Demographic data and aneurysm characteristics in patients without (group 1) vs with (group 2) secondary procedure after EVAR

	Group I (n = 182)	*Group II (n = 68)*	P
Mean age (y)	72 ± 8.7	71 ± 8.5	NS
Male gender (%)	94	93	NS
AAA diameter (mm)	52.2 ± 4.9	55.6 ± 5.1	NS
D/E AAA classification* (%)	7.2	6.8	NS
Score 3 cardiac status† (%)	3	4.4	NS
Score 3 pulmonary status† (%)	6.6	1.5	NS
Score 3 renal status† (%)	1.6	3	NS
ASA 3/4 (%)	63.2	50	NS

EVAR, Endovascular repair of aneurysm; *AAA*, abdominal aortic aneurysm; *ASA*, American Society of Anesthesiologists.
*EUROSTAR classification. D/E includes aortic aneurysm with iliac extension close to hypogastric bifurcation; Includes aortic aneurysm with iliac extension distal to hypogastric bifurcation.
†Society for Vascular Surgery/ISCVS classification.

tion. All endovascular conversion procedures were performed with specially customized aortouniiliac grafts (Zenith; Cook).

Embolization. Inferior mesenteric arteries were blocked at their origins by way of the superior mesenteric arteries. We used either a femoral or a brachial approach, depending on the angle between the aorta and the superior mesenteric artery. The proximal segment of the Drummond arcade was catheterized with a 5F catheter. A 3F microcatheter was advanced to reach the ostium of the inferior mesenteric artery. Five to 10 microcoils (Tornado or spiral coils; Cook), 4 to 5 mm wide and 2 to 3 cm long, were placed to obtain total occlusion of the proximal trunk of the inferior mesenteric artery, while the collateral pathway to the sigmoid arteries was spared. Patent lumbar arteries were embolized with a similar technique. They were catheterized from the hypogastric arteries through the iliolumbar arteries. Whenever necessary, the ostia of the fourth and fifth lumbar arteries were blocked bilaterally. Coils and microcoils were used when the microcatheter could be placed within the sac or at the level of the artery ostia. Histo-acryl glue (Braun, Boulogne, France) was delivered into the trunk of the lumbar artery when the distal tip of the microcatheter could not reach the ostia itself or coils were insufficient. The hypogastric arteries were blocked with coils when a distal extension crossing the origin of the hypogastric was necessary. We strived to block the origin of the hypogastric artery and spare the distal branches. Direct coil embolization of the sac was performed in the operating room, with the technique of Baum et al.[10] The puncture was guided by findings on plain x-ray films. Combined coil embolization and hysto-acryl injection was used.

Thrombolysis. After diagnostic angiography, a guide wire (0.035 inches in diameter, 1.5 m long) and a 5F multiply perforated polyethylene catheter were placed into the clot. Urokinase (Actosolv; Hoechts, France) was injected intra-arterially at a dose of 4000 IU/kg/hr for 4 hours; then infusion was slowed to 1000/IU/kg/hr for 24 to 48 hours. When proximal lysis was obtained, the catheter was advanced farther into the remaining clot. Lytic therapy was continued for 4 hours if complete lysis was obtained. Heparin was injected concomitantly through the introducer at a dose of 20,000 IU/24 hr. Lytic therapy was stopped if the fibrinogen concentration fell below 1 g/L. After lysis, severe stenoses or kinking were stented with either with a Palmaz stent (Cordis) or a Wallstent (Boston Scientific).

Table II. Events that led to secondary intervention after endovascular repair of aortic aneurysm

	n	*%*
Type I endoleak, proximal	7	6
Type I endoleak, distal	29	26
Type II endoleak	33	29
Type III endoleak	12	10
Limb occlusion	13	12
Limb stenosis or kinking	8	7
Graft occlusion	2	1.5
Graft migration	4	3
Iliac enlargement	4	3
Total	112	100

Open adjunct surgery. Subcutaneous femorofemoral bypass or retropubic iliofemoral bypass was performed to treat limb graft occlusion that could not be treated with endovascular means and as an adjunct procedure for endovascular conversion. The repair took into consideration the status of the hypogastric artery, which was spared when feasible.

Cerclage. Banding of the iliac artery with a Teflon sheet was performed through a short retroperitoneal incision. To determine the tightness of the band and to avoid creation of a stenosis while treating the leak, we inflated a balloon within the iliac artery while tying the suture.

Laparoscopic adjuncts. Through a laparoscopic approach the aneurysm sac was opened, clots were removed, and backbleeding from the lumbar arteries was stopped with placement of sutures and clips inside the opened sac. The aneurysm sac was resected and sutured to reduce the volume of the aneurysm.

RESULTS

Among the 250 patients included in the current analysis, group 1 included 182 patients in whom no secondary intervention was performed, and group 2 included 68 patients (27%) who required 112 secondary procedures. Mean time from initial graft placement to the first secondary operation was 18.2 months ± 8.2 months.

Thirty-six patients (53%) required a single secondary procedure, 24 patients (35%) required two procedures, 5 patients (10%) required three procedures, 2 (3%) patients

Table III. Distribution of secondary events after EVAR

		Technical success	
	n	*n*	%
Aortic cuff	6	3	50
Limb extension	32	29	90
Limb interposition	4	3	75
Embolization total	35		
Internal iliac artery	9	7	77
Lumbar artery	21	12	57
Inferior mesenteric artery	5	4	80
PTA with or without stenting	14	12	85
Thrombolysis	4	2	50
Femorofemoral bypass*	9	9	100*
Iliofemoral repair	3	3	100
Iliac cerclage	1	1	100
Laparoscopic repair	1	1	100
Endovascular conversion	3	3	100
Total	112	89	79

EVAR, Endovascular repair of aortic aneurysm; *PTA*, percutaneous transluminal angioplasty.
*Includes two infected grafts that were removed and successfully replaced.

required four procedures, and one patient required five secondary procedures.

Patient demographic data and aneurysm characteristics are shown in Table I. There was no statistical difference between the two groups.

Reasons for secondary intervention are listed in Table II. Of note, in some patients there was more than one reason to perform a secondary operation. For example, migration and kinking or migration and type I endoleak were frequently associated. In addition, some patients had multiple and complex combinations of endoleaks.

Distribution of procedures and efficacy of treating the causes are listed in Table III. Endovascular methods were used in 98 cases (87%), with generally rewarding results, except for failure of aortic cuffs in half of the cases, and early techniques of lumbar embolization. Surgical secondary operations included nine femorofemoral bypass procedures and three thromboendarterectomies, all of which remain patent. However, in two patients groin infections developed that required explantation and new crossover grafts. The outcomes were favourable, with complete wound healing and graft patency. One cerclage of an external iliac limb was initially successful. However, conversion to open surgery was required 8 months later because of a persistent leak from graft fabric rupture and an enlarging aneurysm. In another patient with an enlarging aneurysm and type II endoleak, laparoscopic repair was attempted after failed lumbar embolization. A control CT scan obtained after 1 month showed exclusion of the aneurysm and reduction of the sac size. Overall technical success was 79% (89 of 112), and there were no early deaths after secondary procedures.

We also investigated the role of type of endovascular grafts used in the requirement for secondary procedures (Table IV). Twenty-eight of 160 patients (17%) with supported grafts still commercially available (Cook, Excluder, AneuRx, Talent), versus 32 of 76 patients (42%) with grafts removed from the market (Stentor, Vanguard, Stenway) ($P = .06$) required one or more secondary procedures. Eight of 13 patients (61%) who received EVT grafts (Endovascular Technologies, Menlo Park, Calif) required a secondary procedure. The ratio of number of procedures/patients with grafts still commercially available is 59%, versus 21% for grafts removed from the market ($P = .001$).

Table IV. Distribution of secondary interventions according to type of endograft

Endograft	Group I Patients	Group II Patients	Group II Procedures	Patients with secondary procedure (%)
Stentor	2	6	15	75
Vanguard	40	18	30	31
EVT	5	8	14	61
Talent	5	1	1	16
Stenway	2	8	18	80
Cook	90	21	25	18
AneuRx	17	4	7	19
Excluder	20	2	2	9

Eleven of 250 patients (4.4%) with stent grafts underwent explantation of the grafts, three patients in group 1 (1.6%) and eight patients in group 2 (12%) ($P < .003$). The risk for surgical conversion after endovascular grafting was 15 times greater in patients requiring a secondary operation than in those who did not need a secondary procedure. Concerning type of graft, 6 of 76 grafts (7.8%) removed from the market necessitated conversion, versus 5 of 174 (2.8%) grafts still available ($P = .158$). When comparison is limited to supported grafts still on the market versus supported grafts removed from the market, the difference is statistically significant, respectively, 3 of 160 (1.8%) versus 6 of 76 (7.8%) ($P = .05$).

Nine patients with fully supported grafts were operated on through a midline incision and with infrarenal clamping. Two patients with EVT grafts were treated through a retroperitoneal approach, with suprarenal clamping. Data for these patients are shown in Table V. All patients who underwent conversion to open surgery survived the operation.

Survival rates for patients with and without the need for secondary procedures were, respectively, 98.5% ± 1.4% and 97.7% ± 1% at 1 month, 96.9% ± 2.1% and 95.9% ± 1.5% at 6 months, 93.2% ± 3.4% and 94.4% ± 2% at 1 year, and 88.5% ± 5% and 80.8% ± 5.2% at 3 years ($P = .07$, log-rank test; Fig 3, online only).

Overall clinical success rate of endovascular repair of AAA was 84% (211 of 250) in this series. For comparison between groups 1 and 2, the success rate was 91% (166 of 182) versus 66% (45 of 68; $P = .001$) if all endoleaks on the most recent CT scans are taken into account, and 94% (171

Table V. Data in patients who underwent conversion to open surgery after EVAR

Patient	*Endograft*	*Time to conversion (mo)*	*AAA Initial diameter (mm)*	*AAA diameter at conversion (mm)*	*Endoleak*	*Occlusion/ stenosis*	*Outcome*
1	EVT	3	47	47	—	yes	Alive
2	Talent	4	52	60	Type I, proximal	no	Alive
3	Vanguard	14	72	75	Type I, proximal	no	Alive
4	Stentor	29	58	67	Type I, distal	no	Dead, 7 mo postoperatively
5	Vanguard	38	46	69	Type III	no	Alive
6	EVT	36	55	65	Type I, distal		Alive
7	Vanguard	71	60	60	Type III		Alive (stroke)
8	Stenway	78	52	52	—	yes	Alive
9*	AneuRx	38	80	95	Type I, proximal	no	Alive
10*	AneuRx	3	58	68	Type I, proximal	no	Alive
11*	Vanguard	26	72	80	Type III	no	Alive

EVAR, Endovascular repair of aortic aneurysm; *AAA*, abdominal aortic aneurysm.
*Secondary procedure not attempted, because of large and rapidly expanding aneurysm and uncertainty concerning ability of a secondary procedure to fix the leak.

of 182) versus 76% (52 of 68; $P = .001$) if type II endoleaks without growing aneurysm are not considered failures. Of interest, no rupture was observed in this series.

DISCUSSION

Our study is in agreement with previous reports that underlined the frequent need for repeat intervention after endovascular treatment of AAA. Incidence of repeat intervention was 10% in the Montefiore experience with 239 AAA followed up for 75 months.[11] The Sydney group reported on 266 patients followed up for a minimum of 6 months (median, 24 months), of whom 43 patients required either open repair or supplementary interventions.[8] Our group previously reported a 16% rate of secondary interventions during follow-up.[2,12] The EUROSTAR data base demonstrated freedom from secondary intervention to be 42% at 72 months, as calculated with life table analysis.[7]

The extent, duration, and quality of follow-up, as well as the decision for repeat intervention, are factors that may influence the rate of repeat intervention, and also freedom from rupture and occlusion. The need for aneurysm and stent graft imaging at 1, 6, and 12 months, and yearly thereafter is underlined in all reports. However, apart from monitored research protocols, routine practice may not be so ideal. The rate of rupture investigated by the EUROSTAR data base has been estimated at as high as 1% per year. Rupture was more frequent in cases of graft migration, type I endoleak, and mid-graft endoleak. It may be speculated that early repeat interventions in these cases may have prevented rupture.[13]

Our group has organized a systematic and periodic review of all patients treated in our institution with endovascular grafts. This promoted detection of clinically silent problems and enabled us to initiate treatment before complications occurred. This aggressive policy may have prevented catastrophic events, inasmuch as of yet no rupture has occurred. The cost was a relatively high number of repeat interventions (27%) for the entire series.

There are many reasons for repeat intervention, including technical flaws at operation, material deterioration, and evolution of disease in the arterial tree. Design of early grafts, including some of those used in the current series, was not optimum. The range of sizes was limited, and may have accounted for a number of type I proximal and distal endoleaks. With the Stentor, Vanguard, and EVT grafts, only patients with aortic neck diameter less than 26 mm and common iliac arteries initially 12 mm, then 14 mm, in diameter could be treated. With the more recent grafts, available sizes are increased to 36 mm at the aortic level and up to 28 mm at the iliac level. Limb disconnections observed with the Stentor and Vanguard grafts were due to inadequate overlap between the contralateral limb and the aortoiliac segment. The rigidity of these systems may have also had a role. Conversely, limb and graft occlusion observed with the EVT system was due to overflexibility of the graft[14] and to difficulty in deploying the graft properly. Material fatigue is a concern with endovascular grafts.[15,16] To date, two Vanguard grafts in our patients have had fabric rupture, and conversion to open surgery was necessary. These flaws have been addressed with the newer generation grafts. Thicker fabric and designs that minimize metal-fabric friction give hope for better durability. Furthermore, current results with the newer generation grafts are encouraging.[17] Our study confirms this trend. If EVT grafts are excluded, currently available grafts were associated with fewer secondary procedures and conversions. However, longer follow-up with the more recent grafts is necessary before firm conclusions can be drawn.

Repeat interventions were performed for a variety of reasons and with different means. In our series, type I, type III, and type IV endoleaks were treated with endovascular procedures, most commonly by adding a new piece of endograft at the presumed site of the leak. We found that the most difficult cases to deal with were type I proximal endoleaks. The main risks of putting a new graft in the infrarenal neck are blocking the renal arteries if it is placed too high, and failing to treat the leak if it is placed too low. In addition, mobilization or destabilization of the former graft by the introducer system of the new graft is of concern. Conversely, distal type I endoleaks resulting from common iliac artery enlarging, as well as graft limb disconnections, were generally successfully treated with a percutaneous approach from the groin or a combined groin-brachial artery approach.

Endovascular conversion is, in our view, an excellent tool to precisely deliver a new piece of graft. Proximal cuffs are difficult to place properly, owing to their short length, lack of proximal bare stents, and the absence of hooks. Also, in the long run the proximal cuff may fall apart.[18] With a new aortoiliac graft, handling is much easier and the delivery is more precise. We have chosen the Cook device for this procedure, because we have found deployment to be quite accurate and because we suspect that the presence of hooks may improve long-term fixation. Endovascular conversion is also a useful strategy when one limb cannot be catheterized because of severe kinking or disconnection. This technique had been used with success in similar situations by Teruya et al[19] and Teufelsbauer et al.[20]

Early treatment of type II endoleak is controversial, inasmuch as 60% occlude spontaneously.[21,22] We were relatively aggressive in treating type II endoleaks, especially in patients with very large aneurysms or aneurysms that enlarged during follow-up. Although some may question whether all of our coil embolizations were necessary, we believed that growing aneurysms should not be left untreated. That led us to attempt a substantial number of lumbar or mesenteric coil embolizations, which may overestimate the rate of secondary procedures. Similar to what has been reported by others,[23,24] we were relatively successful in our attempts to block backbleeding from the inferior mesenteric artery through a superior mesenteric approach. However, blocking of lumbar arteries was technically much more challenging, and our early results were disappointing. This confirms the 60% failure rate for type II coil embolization reported by Solis et al.[25] Failures in their series, as in our own, were due to persistent flow though the coils, retiform anastomosis around the coiled vessels, and new type II endoleak. With increased experience, however, we found that coil embolization of all patent lumbar arteries by selective catheterization of both hypogastric arteries was more efficient. In our most recent cases we have used a combination of coils and glue, which seems to work well. In two cases we used direct puncture of the sac, as proposed by Baum et al[10]; both failed. After failed embolization, laparoscopic treatment appears to be a promising approach. While the graft is left in place, the leak can be treated and the aneurysm reduced. This technique was successful in one of our patients. A slightly different approach was reported by Kolvenbach et al,[26] who clipped the lumbar arteries from outside the sac and then secured the graft with a suture to the aortic wall.

Most stenoses and occlusions occurred with the Vanguard and EVT grafts. Kinking or twisting of the limb was the principal cause.[14] When the limbs were still patent and not too angulated, angioplasty with stenting was successful in most cases. When totally occluded, thrombolysis was attempted, with relatively disappointing results. We currently favor crossover femorofemoral bypass when one limb remains patent. Of note, however, is that in two femorofemoral grafts infections developed at the groin. Previous punctures or incisions were probably the main reason.

Surgical conversion was necessary in 4.4% of our cases. This figure is in the range reported by the Sydney group (6.3%, 17 of 266),[8] although most of their conversions were required within the first postoperative month. Our number is higher than those reported from the EUROSTAR data base (1.4%, 41 of 2862)[13] and the Montefiore series (2.1%, 5 of 239%).[11]

In 8 of 11 patients, conversion was performed after failed endovascular salvage attempts (one to five). In the remaining 3 patients conversion was performed primarily because of a large and rapidly expanding aneurysm, and uncertainty concerning the ability of a secondary procedure to fix the leak.

In this group of patients, we chose a transperitoneal route with infrarenal clamping for grafts without hooks, and a retroperitoneal route with suprarenal clamping for failed EVT grafts. With this strategy, surgery was relatively straightforward, the grafts slipped out relatively easily, and outcomes were uneventful.

The most positive finding regarding repeat interventions was the low rate of life-threatening complications. Eighty-seven percent of our repeat interventions were endovascular, requiring only local anesthesia and a short hospitalization. Survival curves showed no differences between patients who required a secondary operation and those who did not. Also, ultimately results were good in the 11 patients with surgical conversion and 9 with femorofemoral grafts. This experience is shared by May et al.[8] Conversely, the Montefiore[11] and EUROSTAR series were less optimistic. In the EUROSTAR series the death rate for conversion, excluding rupture, was 24% (10 of 41).[13]

In the group of patients with repeat interventions, clinical success according to the definition of Reporting Standards for Endovascular Repair was 45 of 68 (66%). It was significantly greater in the group of patients who did not require repeat intervention (94%). For the entire series the clinical success rate was 84%, which falls within the range reported by May et al.[8,17] Zarins et al[27] reported the 4-year Medtronic experience, and showed that in patients treated with endovascular grafts open surgery was avoided after 3 years in 93%.

In conclusion, with close follow-up and a significant number of secondary operations, this 8-year experience has not included any aneurysm ruptures to date. Secondary operations did not lead to increased mortality, but were associated with increased need for conversion to open surgery and with a higher clinical failure rate. The role of endovascular conversion, laparoscopic adjunct, and newer techniques of coil embolization that may reduce the number of surgical conversions after endovascular repair of AAA should be further explored to assess their efficacy. Finally, it may be speculated that with newer grafts overall success will increase and the need for secondary procedures will decrease.

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DISCUSSION

Dr Thomas S. Riles (New York, NY). Do you feel that the glue that you're using for repair is going to be the mainstay of your repairs of these types of leaks in the future?

Dr Jean-Pierre Becquemin. We were disappointed by the use of coil embolization alone. It worked with a single lumbar artery. But with multiple arteries the coils were not sufficient, even with large coils. So it seemed that with glue and coils the rate of closure was improved.

Dr Alexandre C. d'Audiffret (Minneapolis, Minn). Jean-Pierre, did you do the breakdown according to the type of endoprosthesis used? And were the reintervention and complication rates comparable?

Dr Becquemin. We started our endovascular program in 1995 with the late Vanguard stent grafts, and we currently know that these grafts were not perfect. As a matter of fact, many reinterventions were performed in patients with these early generation grafts. We did some statistics that tend to prove that the most recent grafts work much better. However, the follow-up with recent grafts is not long enough to draw firm conclusions.

Dr John H. N. Wolfe (London, England). Very interesting study. Jean-Pierre, I was a little worried about the proximal neck endovascular repairs. That looked very hairy to me, very close to the renal arteries. And I wonder whether, with your information now, you might consider going directly to open repair of that particular problem?

Dr Becquemin. Well, it probably depends on the length of the neck. If you have migration with a relatively long neck, I think it is better to go for ndovascular conversion. Under these circumstances the aortouniiliac Cook device is relatively easy to place within a failing graft. I think it is much more reliable than just to place a proximal cuff, which is short and difficult to handle.

If the proximal neck is short, it may be safer to go directly for open surgery. I agree with that.